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by

James A. Soles*

ABSTRACT

Histologic sections and other special mounts prepared from samples of lung tissue from a Labrador iron mine worker were analyzed by optical and scanning electron microscopy and X-ray diffraction to determine the composition of inorganic phases present. The tissues contain abundant hematite, sparse quartz and rare fibres, possibly an amphibole; the minerals were probably ingested as airborne dust.

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INTRODUCTION

Occupational exposure of miners and plant workers to dust containing biologically hazardous inorganic materials can produce severe respiratory afflictions that jeopardize health and are occasionally lethal. A few cases of pneumoconiosis have developed amongst workers in the iron ore industry of Labrador-Quebec, and pathologists have sought to determine the causes of the disease. Particles of quartz and other silicates common in the dust appeared in neoplastic lung tissue, which suggested that silicosis was the principal affliction. Coated anthophyllite fibres have also been identified in one case, but they may not have been pathogenic (1).

Lung tissue from a patient whose recent occupation was mining and processing of iron ore in the Labrador City region has recently been under study by pathologists at St. Clare's Mercy Hospital in St. John's, Newfoundland (2). Preliminary medical and X-ray examinations indicated that he suffered from a respiratory disorder similar to that diagnosed as pneumoconiosis in earlier patients from the same area. Histologic sections of the tissue revealed areas of fibrosis and the presence of foreign material of two types: discrete colorless, anisotropic, refractory particles which occur rarely; and abundant orange to dark red particles dusted through areas of tissue which appear to have hemorrhaged.

The present investigation concerned the characterization and identification of the foreign materials.

EXPERIMENTAL PROCEDURES

The histologic sections provided by the hospital were examined under a petrographic microscope to obtain optical information on the foreign phases and determine their distribution. The fine grain sizes did not permit their positive identification by optical microscopy, so other procedures were used to assist in characterizing the particles, including:

a) preparation of thick (100 μm) histologic sections from a paraffin-imbedded sample of the lung tissue, to reduce comminution of larger particles that could yield optical data;

b) low temperature ashing* of a 2.5-mm slice of the tissue, for study of the materials by X-ray diffraction, optical microscopy and scanning electron microscopy;

c) digestion of 100 μm sections and 2-mm slices of tissue in sodium hypochlorite to obtain sedimented mounts of residues, also for electron microscopy and X-ray diffraction analyses.

RESULTS

Petrographic Analysis

The histologic sections showed that foreign debris, consisting of abundant dark dust with a red reflectance and sparse colorless, refractile crystals, was present in several different areas of the lung tissue: near blood vessels, surrounding alveoli, dispersed through large masses of fibrous tissue and scattered thinly along inter-alveolar tissue (Figs. 1,2). The reddish particles are mostly of sub-micron size, rarely greater than 2 μm; the larger particles are fragmental with conchoidal surfaces, and are monocrystalline because they are evenly anisotropic in cross-polarized light. The colorless refractile fragments also are granular to shard-like. Only two short prismatic particles were noticed, and no fibres were observed even in the thick sections.

Slow digestion of the thick histologic sections and slices of tissue in hypochlorite solution permitted the inorganic materials to settle through the dissolved organic debris onto the slide beneath. After careful washing and drying, the particles were submerged in immersion oil of a selected refractive index. The indices and birefringence of a few colorless particles matched those of quartz, but no other optical data were obtainable.

X-ray Diffraction Analysis

Low temperature ashing of tissue was found to be the simplest method of preparing a sample for X-ray analysis of the inorganic fraction. The particles remaining were mounted after pulverizing in acetone to disperse hard agglomerated masses (Fig. 3). The diffraction pattern obtained from the ashed samples was principally hematite; quartz is also present in trace amounts (Fig. 4).

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*LFE Corporation, Model 504 Low Temperature Plasma Asher.

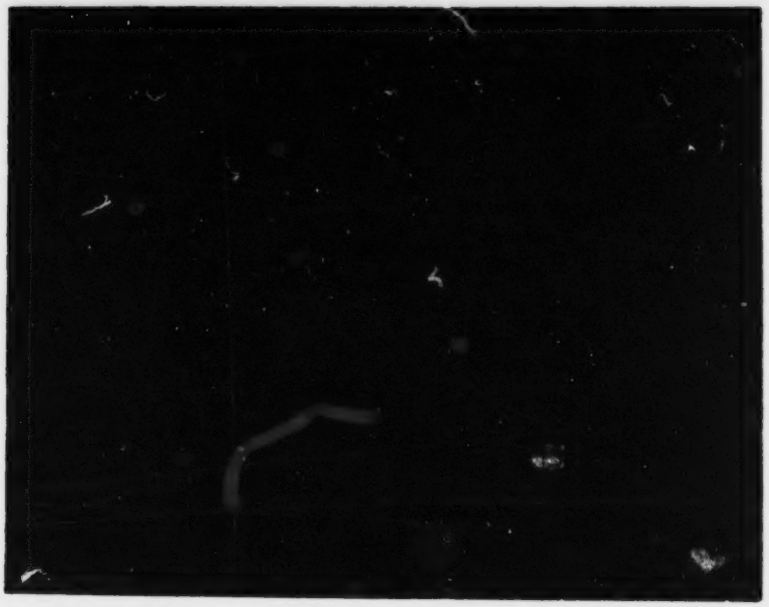

Figure 1. Stained histologic section of lung tissue, showing different organic parts and dark dust dispersed through fibrous tissue surrounding veins and alveoli. Magnification X70.

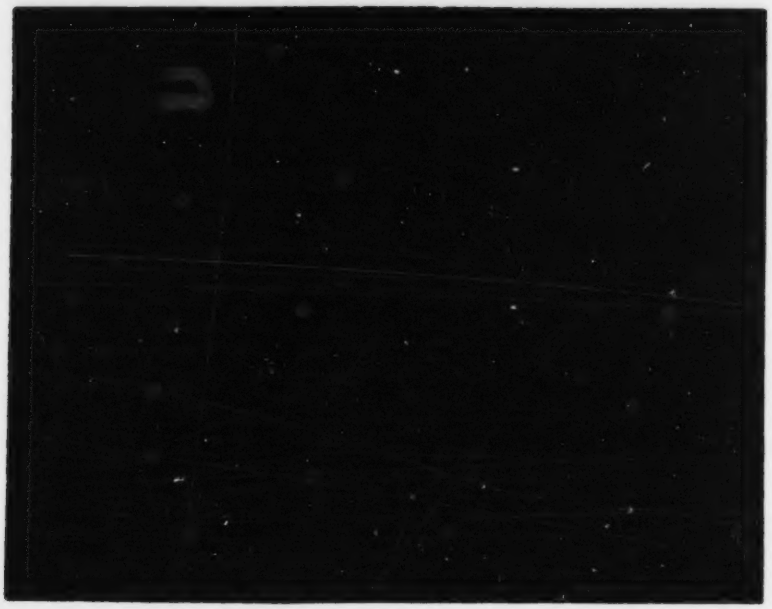

Figure 2. Enlarged photomicrograph of a part of the section, under crossed polarizers. Most of the anisotropic particles are red dust. Five of the larger bright ones in NE quadrant are colorless refractory particles, one of which is prismatic. Magnification X140.

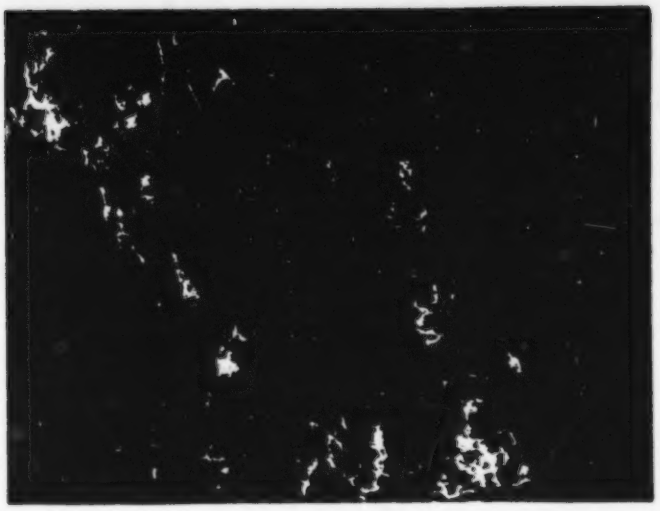

Figure 3. Photomicrograph of ashed lung tissue. White fluffy material is relict cellular tissue; dark central mass is a hard, red, inoxidizable agglomerate containing hematite. Magnification X30.

Figure 4. Debye-Scherrer X-ray diffraction pattern of the pulverized ash, revealing abundant hematite and sparse quartz$^{(+)}$.

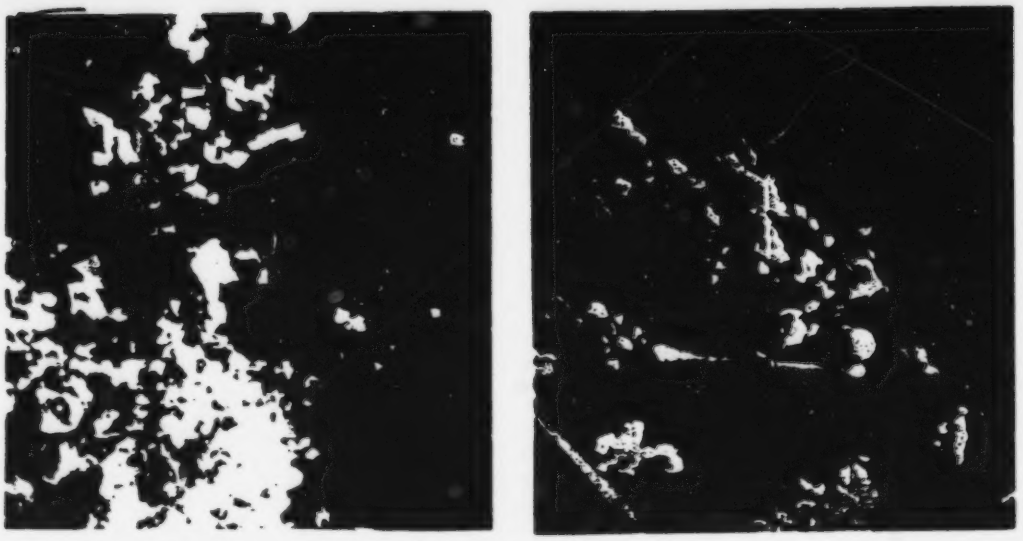

Figure 5. Scanning electron microscopy photomicrographs of lung tissue residue from sodium hypochlorite digestion. Particles are mostly hematite fragments; quartz (Q) is rare, as are fibres which are either bare (left) or coated with ferruginous material (right).

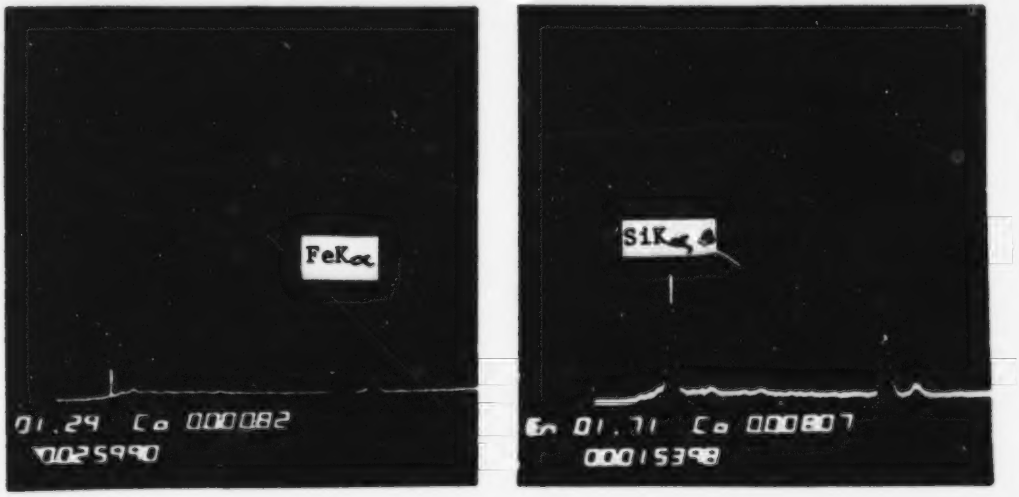

Figure 6. SEM X-ray energy dispersive spectra of hypochlorite residue. Left: the scan of a selected hematite particle showing the predominance of iron; Right: spectrum of the bare fibre in Fig. 5, showing a high silicon content and iron, some of which is probably scattered radiation.

X-ray energy dispersive analyses were made on particles identified optically as quartz and hematite. The predominance of silicon and iron in the respective spectra supported the mineralogical identification. A spectral analysis of one uncoated fibre indicated that it could be an iron silicate containing minor calcium. Positive identification of the mineral phase would require further study.

CONCLUSIONS

The inorganic phases in the lung tissue of this patient have been identified as hematite and quartz; the former is abundant, the latter is sparse. Rare prismatic to fibrous particles, possibly an amphibole, are also present.

ACKNOWLEDGEMENTS

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